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ABSTRACT

This literature review discusses the importance of technology to support teachers' professional development. Section 1, "Technology and Professional Development," highlights technology capacity of America's schools; barriers to effective technology use and professional development (e.g., lack of teacher training and lack of hardware and software); professional development in exemplary schools and districts; and improving professional development in technology. Section 2, "Preparing Preservice Teachers to Use Technology," notes that there are very few studies on the use of technological applications in schools of education, though those that exist indicate that technology can be a powerful tool in helping preservice teachers understand and grasp educational concepts that may be difficult to explain in traditional formats. Section 3, "Technology in Support of the Teacher Development Cycle," highlights teacher competency and school improvement, new competencies for the digital age, and a new type of ongoing staff development. Section 4, "Concluding Remarks: The Teacher of Tomorrow," presents examples of actions that state policymakers can take related to preservice education, teacher licensure, staff development, and technology infrastructure. (Contains 30 references.) (SM)

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Literature Review: Technology to Support Teacher Development

Deliverable for NPEAT Project 2.1.4,

Uses of Technology in Standards-based Teacher Education

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Literature Review: Technology to Support Teacher Development

Today's school children are the first generation of the "digital age." They are being raised in a society that is changing rapidly as a result of the influx of new technologies. New digital technologies are providing more pervasive and faster links to commerce, communication, and culture world wide. The methods used in business, transportation, communication and agriculture have changed dramatically from this influx of technological innovations. As a result, every child's educational, employment and cultural opportunities will be shaped by their ability to understand and manage these emerging technologies. Consequently, the Presidential Committee of Advisors on Science and Technology (PCAST, 1997), the Office of Technology Assessment in Washington (OTA, 1995), and even the Vice President himself (Gore, 1994) have all stated that it is incumbent on the U.S. educational system to make provisions for all children to obtain the skills that are needed to become technologically literate citizens. Without opportunities to access and use digital technology, many of America's children will be confronted with insurmountable barriers that could relegate them to the ranks of the technological underclass with declining opportunities for employment.

Technology and Professional Development

Technology Capacity of America's Schools

Based on recent data (Jerald & Orlofsky, 1999), America continues to invest heavily in technology for schools. For the first time since computers were introduced into America's schools, the student to computer ratio has dropped below 6 to 1. Some critics argue that these numbers are not relevant, instead they believe that we must examine the types of computers that have brought the ratio down so significantly, and rightly so. They believe that simply looking at a student to computer ratio does not tell the whole story. For example, counting old Apple II and 386 computers as part of this ratio creates a false impression of a schools' capacity with respect to technology.

It appears that schools have paid attention to this issue. The older types of machines are being replaced with more powerful models. For example, the ratio of students to multimedia computers dropped from 21.2 to 1 in 1997 to 9.9 to 1 in 1999. Likewise, the ratio of students to Internet-connected computers dropped from 19.7 to 1 in 1998 to 13.6 to 1 in 1999. Further, the number of schools connected to the Internet in 1999 reached 89%, and the number of U.S. classrooms that were connected rose to more than 50% (Jerald & Orlofsky, 1999). Many expect that this number will grow exponentially over the next couple of years to the point that all classrooms will be Internet connected.

Nevertheless, most experts warn that the lower ratios of students to computers and the high percentage of connected schools is no reason to celebrate. When one examines the technological readiness of America's teachers to use and embrace these new teaching tools, it appears that we are a long way from having a digital curriculum. According to a 1999 National Center for Educational Statistics study on teacher quality, it was reported that only 20% of all teachers feel "very well prepared" to integrate technology into their teaching. In addition to being uncomfortable with computer use, data from a national study known as Teaching, Learning, and Computing (Becker, 1999) support the claim that classroom computers were not being used to their fullest capacity. For example, in secondary science classes, students use computers more often for writing than for doing science (e.g., collecting or

analyzing data).

In sum, a school can have the best hardware and software available yet it is unlikely that they will be used well, or even used at all, if teachers are not trained. Training teachers on the integration and use of technology appears to have a significant impact on whether they feel comfortable in using technology. Training also increases the likelihood that they will use software and web sites for instruction. Thus, as schools continue to purchase more and better technology, the benefit to students will increasingly depend on how well teachers are prepared to use these new tools.

Barriers to Effective Technology Use and Professional Development

In his book, *The Road Ahead*, Bill Gates made the statement, "One thing is clear. We don't have the option of turning away from the future. No one gets to vote on whether technology is going to change our lives" (1995, p. 74). This statement is as true for educators as it is for the NASA scientists who work on today's sophisticated shuttle systems. Technology is available in our classrooms and it is changing the way educators think about teaching and the way students think about learning. Given that computers are becoming ubiquitous in America's classrooms, it is important for teachers to have a good understanding of ways these technologies can best be integrated into the curriculum to meet the needs of diverse student populations. Unfortunately, this is not happening quickly enough. The 1999 Education Week survey of 1407 teachers revealed that only slightly more than half, 53 percent, use software to enhance instruction in their classrooms, and only 61 percent use the Web for this purpose. Even more discouraging, almost 4 out of 10 teachers surveyed indicated that their students don't use classroom computers at all during a typical school week. To realize the potential of their investment, schools need teachers who are prepared to develop new learning environments that utilize technology as a flexible tool.

Today, many school systems as well as colleges of education are recognizing the need to provide practicing and preservice teachers with professional development opportunities in technology. A 1995 Office of Technology Assessment report stated that school computers are likely to be used ineffectively

or will be underused if less than 30% of the technology budget is spent on professional development. While, efforts to provide these programs are on the rise, there is still much room for improvement. As recently as 1997, only two states reported that more than 30% of their teachers had received nine hours or more of professional development in technology (Education Week, 1997). However, in the 1998 *Technology Counts* report (Milken, 1998a), investigators found that teachers from almost all states now receive some professional development on the use of technology, and some states even require this preparation for licensure renewal. Eighty-nine percent of the teachers surveyed reported that they had received some training on how to use the computer for instruction; however, the percentages of teachers who had training in high-end technologies such as multimedia and/or on-line activities was quite small.

Even with an increase in professional development opportunities, the majority of practicing teachers still feel unprepared to use instructional technologies in their classrooms (NCES, 1999). Although the majority of the educators in these settings recognize that they live in a world in which technological skills offer increased opportunities for accessing new ideas and information, few believe that they have the skills that are necessary to use these tools effectively or to teach their students to do so.

In a study that examined technology use by rural teachers (Matthews, 1998), it was reported that more than one half of the teachers surveyed perceived themselves as novices in all aspects of technological use, with approximately one third to one half of the teachers never actually using technology for instructional purposes. This study also found that fewer than 30% of the public school teachers used internet technologies in their classroom even though the number of U.S. Schools with internet access increased by 43% between 1994 and 1997 (U.S. Department of Education, 1998). This finding is significant in that many resources for classroom teachers are available on the Web and these data indicate that the majority of the nations' teachers do not take advantage of the opportunities to use this technology to connect their students with other individuals outside of the walls of the classroom. Similarly, the data suggest that the teachers are not likely to use these resources to increase their personal productivity or to support their own professional development.

Wenglinsky (1998) reported that 40% of the teaching force did not receive instruction on how to

use the Internet, and an additional 18% had less than eight hours of staff development on that technology. In a study done by Cable in the Classroom (1997), only 42% of the practicing teachers reported they felt well prepared to use the Internet in their instruction. That percentage may be inflated, as only 10% of principals and 9% of district administrators indicated that their teachers were well prepared to incorporate the Internet into the curriculum. This findings are of particular interest when one considers that the Clinton administration has been particularly vocal about the need to provide all students with access to the World Wide Web by the turn of the century (Gore, 1994) and considerable monies have been allocated to buy the necessary hardware and software to make this a reality.

Teachers' feelings of being unprepared to use instructional technologies may stem from several factors. First, when professional development is available, teachers typically receive only basic knowledge about the way they should operate the computers and software, not information on how to integrate the technology into instruction or on how to assess its benefits (Milken,1998b; OTA, 1995). Since few teachers entering the profession prior to the mid-1980s received instruction that included technological applications, school districts appear to be concentrating their efforts on training teachers to use the hardware, rather than how to integrate use the technology to make positive changes in the way students think and learn.

The content of the technology training has been shown to influence how useful it is (Kennedy, 1999). Technology training that is aligned with the curriculum and is relevant to what teachers do in the classroom is most effective. Training in the integration of technology into the curriculum is nearly always more helpful than basic technology skills training alone. However, a combination of both integration and skills training is reported to be most effective (Trotter, 1999).

Unfortunately, many schools have spent thousands of dollars to purchase computers or to upgrade their instructional computing capacity with the hope that the mere presence of these technologies will promote positive instructional changes. These schools quickly discover that technology alone does little to support changes in the way teachers think about teaching and the way students think about learning. These types of changes represent a modification in a teacher's pedagogical belief system, not simply a change in the tools that are used to facilitate this process. In fact, the data that

exist on the effectiveness of computers and related technologies to increase student learning is equivocal in nature. While some studies have reported that computer technologies produce positive student outcomes when used in instructional settings, others report very different results. Consequently, parents, teachers and school administrators are often uncertain about the real benefit of these technologies as instructional tools. Interestingly, in cases where technology-based instruction has been successful, the research suggests that it is most often the result of using the computer to deliver well designed and well managed instruction (Hasselbring & Williams Glaser, 1999). Thus, the focus is once again placed on the teacher's actions in the classroom rather than on the technologies that were utilized in that setting.

Further, studies have found that uses of technology are limited by both the quantity and quality of the hardware and software available in the schools. While the number of computers in the schools has increased in recent years, the inequitable distribution of hardware and software is a problem, often referred to as the "digital device." For example, *Technology Counts 98* reported that the groups most likely to lack technology access include Hispanic students, students in large schools, and students who attend schools populated entirely by minority students. Affluent schools that are not eligible for federally subsidized lunches are much more likely to be technology rich, as are schools with low minority enrollments (U.S. Department of Education, 1998). Further, low-income and minority-serving schools that do have technology, however, tend not to integrate it productively. More than 50% of African American students have teachers who use computers mostly for drill and practice, as compared to only 30% of white students (Educational Testing Services, 1996). Consequently, it is critical to structure professional development opportunities in such a way as to keep the focus on the integration of technology into the curriculum in ways that help teachers use these tools most effectively.

The absence of teacher technical support is another barrier to effective use of instructional technology. Teachers are not given time to plan for the integration of the technology into their curriculum (Milken, 1999). Often, those who do integrate the technology lack the support from colleagues who are not available to plan collaboratively. Only 29% of schools have a full-time technology coordinator (Milken, 1998a), and those who do mainly employ that person to teach children computer skills instead of providing technology support for teachers (Becker, 1994a). Strudler (1994) found that teachers frequently cited the need for on-site technology support. Fullen and Stiegelbauer

(1991) noted that people need support in the early stages of implementation, because it is at this time that people most often have concerns and self doubt. Interestingly, even though there are many references n the literature base on technology integration the need for technology support there is little research that focuses on the effectiveness of or need for on-site technology support for classroom teachers (Prestidge, 2000).

Evans-Andris' (1995) conducted a longitudinal study in twelve elementary schools where technology-coordinators were employed. Her findings revealed that in order for a technology coordinator to provide effective support to classroom teachers, it is imperative for the coordinator to be in the school on a full-time basis. Evans-Andris also noted that technology coordinators should work *with* teachers rather than working *for* teachers if they are to be effective in helping teachers use technology in meaningful ways. The data clearly indicated that the coordinators felt that they were seriously hampered in their attempts to promote the integration of technology because they believed the classroom teachers wanted to have someone else "worry" about using technology rather than trying to learn to integrate it themselves. In addition, the coordinators often felt that their responsibility was to do little more than provide the teachers with some additional planning time and consequently they felt their role was diminished. Several coordinators noted that their tasks were often harder in schools in which the principal also held this belief. The data clearly indicated that although these schools did have technology-coordinators, there was little communication between teachers and coordinators around curricular topics and resultingly, the integration of technology left a lot to be desired. Evans-Andris concluded by saying that the findings of her study suggest that it may be more appropriate to hire technology coordinators as resource facilitators in order to work with teachers to identify ways that the technology can best fit into the curriculum rather than doing this for them.

Winnans and Brown (1992) noted that there are situations in which the very person that is supposed to provide technical support becomes one of the primary obstacles to the integration of technology. This research indicates that professional jealously, and an ambiguous understanding of the job responsibilities are factors that can cause friction between support personnel and classroom teachers, thus eliminating any opportunities for these people to work together to integrate technology into the

existing curriculum.

In contrast to the previously mentioned studies, Prestidge (2000) found that employing a full time technology coordinator offered unique opportunities for teachers to collaborate with each other and the coordinator about the ways technology could change their teaching and create learner centered classrooms. This two year qualitative study was designed to evaluate the impact of the infusion of technology on teaching and learning in a private girls preparatory school. Prestidge, who was employed as the technology coordinator for the school acted as a participant researcher. In addition, a network supervisor was hired to maintain the network, computer hardware, system software and provide limited technical support to teachers. In contrast, Prestidge served as the curriculum specialist. This role evolved from the original position of the technology coordinator who was initially hired to operate the school's computer lab. Interestingly, the new title did not include the word "technology", thus, clearly indicating that the school had made a commitment to focus on ways the technology could support the curriculum rather than being seen as an entity unto itself. The role was described as a consultant who would work with teachers to help them determine the most appropriate way to integrate technology into the curriculum. A technology support team, which included the curriculum specialist, the librarians, and the network supervisor worked together to support teachers, to trouble shoot, to consult with teachers, to review proposals for purchases of technology, and to problem solve.

Findings from the study clearly showed that the training opportunities that were offered were highly valued. Week-long training sessions were offered on a schedule during the school day and during the summers, thus offering multiple opportunities for teachers to think about and experiment with technological tools, applications, and concepts of the ways these might enhance their instruction. Teachers also valued the opportunity to consult with the curriculum specialist and reflect on their instructional practices. They felt that this method of infusion did not force them to "sacrifice" their teaching to the "Great God" of technology and that their instructional goals were valued. The consultant model also placed the responsibility for infusing technology squarely in the teachers' hands, yet, at the same time, offered support on multiple levels. Most significantly, this model resulted in teachers wanting to be technologically "independent" and self sufficient in technology use and problem solving. The teachers wanted to know how to "fix things" and to make decisions because they did not want to

"miss a step" or "lose time." The curriculum specialist and teachers had a collaborative relationship that supported the teachers as they refined their instructional strategies and uses of technology. They noted that this process resulted in benefits for both students and teachers. Many teachers stated that while they did not set out to change their instruction, "it just happened."

Interestingly, although several reports cite equipment, software, time, and training as the most common barriers to the integration of technology, the elimination of these barriers does not necessarily facilitate a smooth transition to technology use by classroom teachers (Hall, 1997; Rieth, 1995). In a study which was designed to train and support school-based teams of teachers and administrators to use technology, researchers found that even when they eliminated all the "known" barriers to the integration of technology in five elementary schools, they were still faced with significant obstacles to the integration of technology into the schools' classrooms. In this situation, the project coordinators placed a great emphasis on helping the school-based teams use technology to create constructivist environments which supported higher level thinking skills. This model, which included a mentoring relationship between the university and the schools, was well received by all the school-based teams. Unfortunately, during the third year of the project, the school system chose to institute a system wide "core"curriculum which focused on the obtainment of basic skills. Consequently, teachers and administrators felt they were under significant instructional constraints and eventually, many of the schools chose to "go back" to using technology for drill and practice activities (Williams Glaser, Hasselbring, Rieth, & Prestidge, 1999). This particular study was conducted in schools in which the principal had agreed to be an active participant in the workshops and classroom activities and to provide the necessary administrative support for teachers to successfully integrate the technology into their classrooms. The administrator's role in this process was crucial to the success of the project during the first two years. Additionally, the principal also made many of the executive decisions regarding the role that the technology would play once the "core" curriculum was mandated system wide. Seller (1993) notes that administrative support is a key to the successful integration of technology. Similarly, the lack of administrative support to provide planning time and support for new teaching constructs severely stymies the integration of technology.

Similar results were obtained in a survey of 298 elementary and secondary teachers who had

participated in a state-mandated technology training program associated with the funding of Tennessee's 21st Century Classrooms (Lewis, 1997). The results of this study noted that teachers felt that there was (a) insufficient time for experimenting with technology and (b) problems with the quality and timing of the training, (c) the length of time that elapsed between training and the acquisition of technology, and (d) problems of malfunctioning technology. Prominently mentioned were issues related to a lack of time to use the technology effectively due to the imposition of a state-mandated curriculum which focused on the breadth of material rather than an in-depth look at the subject matter.

As might be expected, time is another barrier to effective technology use and professional development. On average, teachers spend between one and eight hours per year of professional development time on technology training and typically receive more time on basic skills training than curriculum integration training (NCES, 1999, Milken, 1998). Teachers who receive more than eight hours of training tend to feel more prepared to integrate technology into their curriculum than those teachers who receive less. Of those who received more than eight hours of technology integration training, 33% felt "very well prepared" to integrate educational technology into the grade of subject they taught, compared to 17% who received up to eight hours.

In summary, professional development opportunities in technology are increasing, however, they are insufficient to produce the kinds of changes that are needed in today's teachers. More opportunities need to be made available and more emphasis must be placed on the integration of technology across the curriculum. The time, quality and scope of technology related professional development provided to teachers clearly impact the type and degree of technology use in their classrooms.

Professional Development in Exemplary Schools and Districts

In studies of exemplary technology use in schools and districts, the importance of professional development continually surfaces as a factor of success. The Beryl Buck Institute for Education (BBIE, 1995) conducted case studies of school districts that were widely recognized for their excellence in

preparing teachers to incorporate technology into their instruction. Their findings supported those of Becker (1994b), who investigated similarities within districts that contained exemplary teachers. School districts described within the BBIE report and in the Becker study invested a great deal of time in staff development and technical support, including multiple exposure to the same concepts (BBIE,1995; Becker, 1994b). Progressively, the support focus shifted from providing technical "how–to" information to supplying instructional mentoring, the provision of examples of teachers who are using technology effectively and could offer concrete suggestions on how it could be better used.

The findings of Glennan and Melmed (1996) also highlight the importance of staff development with respect to the successful implementation of instructional technology in a school system. They identified five technologically-rich schools whose districts attributed their success to technology. These schools, while being more densely populated with technology than the typical American school, served varied populations. Teachers reported improved attitude, participation, and standardized achievement scores. While the schools varied in expenditures per pupil and the use of technology, they all offered some form of staff development for their teachers. Staff development opportunities ranged from a year's paid leave to learn more about how to use technology to one day a year for inservice and access to a lab for practice. All schools had a technician/coordinator position who provided teacher support.

MacArthur et al. (1995) conducted research on a project that was designed to provide inservice education opportunities and continued school-based support to teachers who were attempting to use technology through a university- and a school district-mentoring program. The program prepared experienced technologically proficient teachers to serve as mentors to other teachers in the school system. The goals of the program were to (a) increase knowledge of computers and teaching for both mentors and their partners and (b) establish collegial relationships between schools that would continue long after the mentor program came to an end. Over a three-year period, 59 mentors and 154 proteges in 24 schools participated in the project. The results of the formal study indicated that both mentors and their partners developed an increased knowledge of computer applications. Additionally, while both parties continued to use technology in a variety of ways in the classroom setting, the proteges made extensive changes in the way they used technology both for professional tasks and in their work with

students in their classes.

The administration and staff in the effective districts also focused on long-term planning to implement instructional technology. They decided upon the goals and objectives for using instructional technology and then allocated financial resources accordingly. They realized that their plans would need revision as the implementation progressed and that large amounts of time and money would be needed. They also prepared for staff turnover by providing the teachers with continuous exposure to the theoretical constructs that guided the implementation of the technology plan (BBIE, 1995).

Findings regarding effective technology-using districts mirrored characteristics of effective teachers. Districts that integrated technology well had cadres of computer–using teachers in schools as opposed to one teacher per school using technology. They also had smaller class sizes, more software, and more teacher planning time, as well as a great deal of collaboration among students (Sivin-Kachala & Bialo, 1996).

In summary, a district commitment to the use of instructional technology is vital to its successful implementation. This commitment involves developing a long–range technology implementation plan. The research suggests that the plan should include increasing funds and time allotted for staff development and hiring staff to provide instructional and technical support for the teachers. It should also provide more technology for the classrooms.

Improving Professional Development in Technology

What can be done to improve the quality of instructional technology preparation for teachers and increase the number of exemplary teachers integrating technology? Several studies indicate that increased teacher support is needed to ensure that instructional technology implementation continues and improves. Hadley and Sheingold (1993) reported that schools with a larger number of teachers using technology tended to have more exemplary technology users. These findings suggest that districts might find educational benefits from populating schools with clusters of technology-using teachers to serve as on-site models of how best to integrate technology into instruction. Further, providing teachers with

release time to observe their more experienced peers and to plan collaboratively with them might encourage technology implementation by both experienced and non-experienced teachers (Hadley and Sheingold, 1993; Milken, 1998a). According to Gersten, Woodward, & Morvant (1992) and Hall (1997), this collaborative planning is necessary in order to implement effectively concepts learned in staff development.

In addition to increased staff development, school districts need to reassess their goals for instructional technology, decide how technology can best support the curriculum, and plan their purchases of hardware, software, infrastructure, and teacher support accordingly (Milken, 1998b). The overall district technology plan should be evaluated to determine if the programs are sound. Jordan and Follman (1993) suggested that a good technology program should use cooperative learning models, incorporate higher-level thinking skills, as well as reinforce basic skills, increase communication between students and teachers, relate the skills to "real life" situations, and be flexible enough to address different learning styles.

The Office of Educational Technology (OET) held a conference in 1995 which related some of the Department of Education's principles on professional development to the specific field of educational technology. The conference reiterated that professional development should be ongoing and intensive as opposed to the "one-shot" attempts that Ryan (1991) found to be ineffective. Efforts should also be made to support the teacher's integration of the technology into their regular instruction as a tool rather than as a separate subject. This would involve not only teaching skills but also changing teachers' perceptions of how technology would benefit their classrooms. The conference participants also suggested that inservice instruction be hands-on and conducted using the hardware and software that the teachers have available to them. As to personnel, the participants recognized that teachers needed time to participate in professional development, collaborate with peers, and practice using the technology. A final recommendation was that the school community should commit long term to improving their use of technology. The participants emphasized the importance of the community, school leaders, families, and students planning together how technology can better support student needs (U.S. Department of Education, OET, 1995).

In summary, reviews of research on inservice teacher professional development agreed that the components of time, sufficient hardware and software, formalized instruction, a technology plan, support, and teacher motivation and commitment play a vital role in increasing effective integration of technology into the classroom. These components can be addressed by the state and local school systems; however, a partnership between the public school system and universities would provide a more solid educational foundation for the teachers.

As school districts work to improve their current professional development opportunities in the area of instructional technology, they will need access to more research which focuses on the broader impact technology has in schools and in districts. Most of the work done thus far relates to specific technology initiatives with their own support systems rather than how technology is used by teachers with only district support. Researchers need to continue to explore the relationship between teaching practices and technology use. As Becker (1994b) acknowledged, "We must begin to produce systematic evidence that the kinds of teaching practices that we assume to be exemplary (i.e., the focus on writing, problem solving, and inquiry; and discovery-based learning) do result in the kind of improvements in student competencies that cognitive science research has implied is possible" (p. 319).

According to Sivin-Kachala and Bialo (1996), the "effectiveness of educational technology depends on the match between the goals of instruction, characteristics of the learners, design of the software, and the technological implementations made by teachers" (p. 5). This being true, the case for improved teacher professional development becomes even stronger. Well-planned inservice preparation and continued support are needed in order to increase the number of effective teachers using instructional technology.

Preparing Preservice Teachers to Use Technology

The OTA report (1995) on the use of technology in education provides evidence of how little the digital age has impacted the way teaching is being conducted in this nation's classrooms. Recent

research indicates that even though the need for technologically proficient teachers has grown tremendously over the last ten years, few teacher preparation programs are adequately preparing their graduates to use technology in meaningful ways (Beaver, 1990; Hill, 1992; Pelgrum & Plomp, 1993; Strudler & Wetzler, in press). Clearly, the task of reeducating the existing teaching force to understand and use technology effectively is huge and will require extensive professional development over many years. However, the problem will be exacerbated if those teachers entering the profession now and in the future have not been adequately prepared to use new and developing technologies. Bringing about the needed changes in teacher education programs will not be easy. Change will not occur by simply adding a course or recruiting a new faculty member who understands technology. What is required is a transformation of the culture of teacher education, one in which technology is seen as changing relationships between students and teachers and between learners and knowledge.

Although new ideas regarding the relationship between instructional strategies and student outcomes are being challenged in all areas of baccalaureate education, they hold special significance for colleges of education where issues of teaching and learning are the central features of the curricula. Typically, early efforts to introduce preservice teachers to technology were addressed by offering stand-alone "technology for teachers" courses. However, many of the leading schools of education quickly became dissatisfied with the results of these attempts. It quickly became apparent that stand alone technology courses were of limited value to preservice teachers, primarily because the approach did not provide aspiring teachers with a model for using technology in classrooms (Callister & Burbles, 1990).

Similarly, a recent national survey, the Milken Exchange on Education Technology (1999) found that stand-alone course work is not a good predictor of technology proficiency among graduating teachers, rather the best predictor was the extent to which technology is integrated during college training. Consequently, several schools of education abandoned the stand-alone courses in favor of the integration of technology into the entire educational curriculum offered to preservice teachers. Other schools maintained that a "fundamentals" course can provide a solid foundation for integration in other courses (Downs, 1992; Wetzel, 1993).

Regardless of the perspective on introductory courses, most experts agree that more is needed. Unless students see the use of technology modeled in their courses, unless they have an opportunity to make the connection between technology and instruction in the subject or grade level they will teach, unless they have the opportunity to see the effective use of technology modeled in classrooms and have an opportunity to use it themselves under the guidance and mentorship of experienced practitioners, they are likely to graduate with limited professional skills in the area. In addition, these preservice teachers are likely to harbor a questionable attitude toward the use of technology in education (Collins, 1994; Wetzel, 1993; White, 1994). Thus, it is clear that if schools of education hope to produce future teachers who can effectively integrate technology into the curriculum in meaningful ways, the focus of the training must be based in solid principles of instruction rather than on the obtainment of technological skills. Though the mandate is clear, the means are not. In short, colleges and schools of education have made the same mistake as K-12 schools: treating technology as a special addition to teacher education curriculum. By segregating technology from the mainstream education courses and placing specially prepared faculty in specially equipped classrooms, many schools of education have subconsciously promoted the concept that technology is a subject to itself--rather than a topic that needs to be incorporated across the entire teacher education curriculum (National Council for the Accreditation of Teacher Education, 1997; Office of Technology Assessment, 1995). Few faculty members have the necessary skills to model technology use for students in appropriate contexts (Parker, 1996). The majority of these individuals learned to teach in the manner in which they were taught--through lecture-based courses (Cifuentes, 1997; Gaff, Ratcliff, & Associates, 1997; Huang, 1994). Consequently, like many public school teachers, many university faculty feel that they are unprepared to use instructional technologies in their courses (Roblyer & Barron, 1993).

Additionally, few materials have been developed to help faculty who want to incorporate technological tools into their instruction (Green & Gilbert, 1995; Parker, 1996). A thorough search of the literature revealed that while a great deal of information existed on the ways that technology was being adapted for use in other disciplines, only a handful of studies on the use of technological applications in schools of education exists. However, the research that has been published indicates that technology can be a powerful tool in helping preservice teachers understand and grasp educational concepts that may be

difficult to explain in traditional formats.

Technology in Support of the Teacher Development Cycle

State and local districts have been experimenting with the use of technology in the education enterprise and, more specifically, the teaching and learning process for over three decades. Early pioneers learned that adding technology to schools could be an expensive fiasco as software was purchased without consideration of hardware or expensive computer equipment sat idle in classrooms where teachers did not know how to use the equipment. Further, early computer applications often were not more than "ditto sheets on the screen" as software was developed for drill and practice rote learning (NASBE, 1994).

To significantly impact the professional development and education of teachers so that they are able to utilize the full potential of technology in the classroom, states have realized that they must focus on all policy levers that are available in a systemic fashion. That is, state policy makers must:

- first, identify the system of *professional development* that their state is creating;
- second, identify the key *policy levers* within that system that need to be addressed; and
- third, *infuse those policy levers* with technology-specific dimensions.

Teacher Competency and School Improvement

For many years, educators and policy makers relied on research conducted in the 1960s to make the argument that teaching and schools do not significantly impact a student's educational outcomes. Rather, according to the Coleman (1966) study, a student's personal characteristics and home environment (i.e., socioeconomic status) were more powerful in determining student achievement. However, recent research has shown that teachers are the single greatest influence on student achievement, even greater than socioeconomic characteristics (*EdWeek*, 5 May 1999). A recent study in

Texas found that 40% of the variance in students' reading and mathematics achievement in grades one through eleven could be attributed to teacher expertise, which was more than any other factor. A Tennessee study determined that the single largest factor affecting academic growth, particularly with lower-achieving students, was the effectiveness of individual classroom teachers. Furthermore, research over the past several years has given us greater insight into how children learn. New findings have helped teacher educators and policy makers hone in on the teacher qualities and practices that lead to student achievement. As was noted in the 1996 report of the National Commission on Teaching & America's Future (p. 6):

> *Research has discovered a great deal about effective teaching and learning. We know that students learn best when new ideas are connected to what they already know and have experienced; when they are actively engaged in applying and testing their knowledge using real-world problems; when their learning is organized around clear, high goals with lots of practice in reaching them; and when they can use their own interests and strengths as springboards for learning.*

In addition to knowing their subject well, good teachers also know (p. 6):

- how to motivate students;
- how to break complex subjects and processes down so that students can learn them;
- how to teach their subject in a variety of ways to match the learning styles of their students;
- how to assess student achievement and diagnose problems in student learning; and how to use student assessment data to alter instruction to meet the needs of students.

Over the past several years there has been a growing consensus around the knowledge, skills, and dispositions needed by teachers to be effective in the classroom. These are being translated into standards for beginning and full teacher licensure in states across the country. The work of the states has been two-fold:

(1) Identifying and codifying teacher standards that reflect the research on effective teaching as well as reflect student standards in the state.

(2) Aligning state policies, and in some instances, creating state structures that support a coherent, career-long system of teacher development consistent with state teaching standards.

The full teacher development continuum has several elements:

A shared understanding of what teachers should know and be able to do. In today's parlance, this shared understanding is called *teaching standards*. Standards are hard-edged statements about what teachers ought to know and be able to do and what dispositions or attitudes they should possess. Teacher standards answer the question: What is an effective teacher? Standards should be the basis of teacher education, teacher licensure, and ongoing teacher professional development. That is, they should undergird the entire system of teacher development.

A "pipeline" into teacher education that encourages a talented and diverse pool of teacher candidates. To develop the desired pool of candidates, state policies must extend far beyond the college of education. State policies must cultivate a talented and diverse pool of candidates first to *qualify* for entry into teacher education; next, *choose* to enter teacher education; and then provide supports and services to some candidates to so they can *complete* teacher education programs.

Teacher education processes that specifically target the development of subject matter knowledge *as well as* how to teach that knowledge to a diverse group of students. A comprehensive system of teacher development infuses teaching standards into teacher education. Teacher education includes rigorous discipline-specific instruction, instruction in child development, and instruction in how to teach subjects-- content-specific pedagogy. Many states are in the process of changing teacher education program approval requirements to include candidate performance requirements in the process.

Initial teacher licensure requirements that rely on what a beginning teacher knows and is able to do (i.e., the state's teacher standards), rather than merely the list of courses that a prospective teacher took. College transcripts have proven a poor surrogate for teacher assessment in the past. There has been a great deal of activity in teacher licensure requirements over the past 15 years. Overall, states are

moving toward performance-based licensure, with states and teacher education programs defining the knowledge and skills that teachers must demonstrate *before* they are able to obtain a license.

Teacher induction programs that provide new teachers with mentoring and support to navigate the first challenging years of teaching as well as provide specific guidance in how to apply the knowledge gained in pre-service teacher education. The specific characteristics of teacher mentor programs vary. Some programs are designed to provide social and psychological support to new teachers, while some are designed to provide strictly program support in instructional techniques and classroom management (AFT, 1998). Some mentor programs are formally structured with specific classroom observation and meeting times scheduled between the mentor and new teacher; some programs are less structured with the mentor and new teacher meeting on an "as needed" basis.

Full teacher licensure requirements that delineate a level of achievement of the teacher standards that is beyond the novice level of a beginning teacher. The entire structure of the state teacher license has changed significantly over the past two decades. Most states (47) require teachers to participate in professional development in order to renew their license (CCSSO, 1998). The most common requirement for licensure renewal is six semester credits every five years (CCSSO, 1998). However, some states have moved beyond this traditional format and are now allowing a variety of forms of professional growth including special projects, teacher-lead inquiry, serving as a mentor teacher, and fulfilling personal professional development plans as fulfilling the professional development requirement for licensure renewal.

A process and structure for continued professional development throughout the course of a teacher's career. As noted above, licensure renewal has provided one structure for encouraging ongoing professional development throughout a teacher's career. However, as noted by Corcoran (1995), states are using a variety of policy instruments to support professional development including: mandates, inducements, capacity-building activities, and system-changing activities (p. 32):

- Mandates. Examples of state mandates include: required inservice days (that the state may or may not pay for); licensure renewal requirements; standards for professional

development; and mandatory local budget set-asides for professional development activities.

- Inducements. Examples of state inducements include: salary increments of the state salary schedule; state-funded discretionary programs for professional development; teacher recognition programs; and support for National Board certification.

- Capacity-Building Activities. Examples include: teacher academies; regional professional development centers; training for local staff developers; and peer mentoring.

- System-changing Strategies. Examples include: professional development schools; support for teacher networks; career ladders; and school-based staff development.

It seems clear that technology has the potential to affect professional development in significant ways in the foreseeable future. How that potential will be realized, and whether education will be better as a result, remain to be seen. The basic assumptions underlying these questions are, to a large degree, within our control. The teacher development cycle affords a number of opportunities for the integration of technology. Clearly, some parts of the cycle offer greater opportunities for infusing technology than others.

New Competencies for the Digital Age

What are the specific competencies that are necessary for successful teaching and learning in the digital-age classroom? From 1998 through 1999, the Milken Exchange on Education Technology convened several meetings around this question. One of the difficulties that is encountered in attempting to devise a response lies in establishing boundaries. As education technology is always used in combination with a set of management and instructional strategies, it is difficult to extract a set of technology skills that are distinct from that context in which those skills are applied. The participants in this process agreed that the complete set of skills for the successful use of technology for learning must include a combination of skills related to the successful use of the tools of technology as well as the pedagogical skills associated with the classroom uses where the use of technology had been

demonstrated to be most powerful.

The use of technology in support of the teacher's own professional practice must be emphasized. Teaching is historically an isolated profession. Technology provides the opportunity for educators to access rich libraries of resources and participate in professional discourse at levels that have not previously been possible.

A final area of competency noted by the Milken groups was that of administrative competency. Of particular note was the building principal's competency. Administrators are often the gatekeepers who control classroom access to technology and who guide the culture of the school in ways that can either support the innovative use of learning technologies or stymie it. In virtually every successful school wide implementation of technology, there can be found a knowledgeable and supportive building administrator who is adept at leading and managing systemic change.

These leaders identified five key areas within which educators must achieve competency. These five areas are:

Core technology skills: This category deals with competencies that might be considered as "baseline" technology skills that are necessary for educators to function in the technology-rich classroom. The skills in this category are those related to the use of computer, peripherals and non-computer hardware; basic and specialized software applications; network and information access tools; and multimedia and presentation tools. While many of these competencies have been described as short term and fairly mechanical, they are also crucial in establishing the comfort level that allows educators to begin to consider issues related to curriculum and instruction.

Curriculum, Learning, and Assessment: This area, which lies at the heart of any school improvement initiative, covers a broad area with three interwoven components:

Curriculum: Educators must become adept at devising uses of technology that directly address

and support academic standards at the state and local levels.

Teaching and Learning Strategies: The technology-rich classroom offers the opportunity for the enhancement of a wide variety of instructional strategies. In a study completed this year by the Milken Exchange, West Virginia schools were able to effect an 11% increase in student achievement in reading and mathematics through a combination of basic skills software and intensive teacher training in the appropriate use of that software. In a study reported in the 1998 edition of *Technology Counts*, Wenglinsky of ETS reports that the students of eighth-grade mathematics teachers who use technology for high-level problem solving and simulations perform at significantly higher levels on the NAEP mathematics test. These studies demonstrate that a wide variety of teaching and learning strategies can be successfully supported through well-designed, intentional application of technology.

Assessment: Assessment addresses both the skills of assessing the new products and performances that are possible in technology-rich classrooms as well as the use of technology to support and streamline the assessment process. In Greenbrier, Arkansas students are using high-level Geographic Information System (GIS) and database software to create real-world solutions to problems faced by the city government. Police officers who previously spent over two hours completing an accident report are now able to complete the same report with more accuracy in minutes. New capabilities added by the students allow them to plot and map accident data to devise improvements in traffic safety. Traditional assessment tools are not very useful for students involved in these authentic projects. New strategies are available and educators need to become familiar with these strategies.

Professional and Collegial Practice: Technology has the potential to transform the professional environment within which educators currently function. The application of network and communications technologies to research, collaborative planning, and professional development are the central concepts developed in this area.

Classroom Management: While the complexity of the classroom environment increases significantly with the introduction of technology, so do the opportunities for creating an exciting and purposeful environment for learning. Competencies for educators addressed in this sections include the organization and use of technology resources, the location of and access to technology resources, and instructional management issues in the technology-rich classroom.

In order to support classroom teachers in the development of the proficiencies described above, administrators must be prepared to lead significant change initiatives and play an active role in the professional development of all staff within their area of responsibility.

A New Type of Ongoing Staff Development

Staff development is embedded in systems that profoundly affect its effectiveness. Therefore, school leaders must address structural issues as well as the learning needs of individual school employees. That means that principals must see themselves not only as leaders of learning communities and models of career-long learning, but as "school designers" who create structures that support high levels of learning. Current reality, unfortunately, differs in many important respects from that vision.

Policy makers need to consider what combination of local, state, and federal policies will inspire and sustain changes in individual and organizational performance in a way that causes virtually all students and staff members to learn and perform at high levels. Staff development—the discipline that addresses the knowledge, skills, and attitudes of school employees—lies at the core of this issue, which means that staff development policy is central to the success of meaningful school reform efforts.

Two basic assumptions underlie quality staff development:

- High levels of learning for all students and staff members require deep change in schools and school systems. Structural and cultural factors that surround professional learning support or hinder the implementation of staff development efforts; and

- Staff development is essential but must be significantly different if it is to produce high levels of learning for students and staff members (Jones, 1998; Sparks & Hirsh, 1997). This staff development must have as its core process a "community of learners" whose members accept joint responsibility for the high levels of learning for all students represented by the teachers in the group and who meet regularly to learn, plan, and support one another in the process of continuous improvement.

A school's vision and goals provide a powerful context for a new kind of staff development that is results-driven, standards-based, school-focused, and job-embedded and occurs within a community of peers. Effective staff development is built on a core set of ideas and beliefs, matched to the instructional processes desired in classrooms, and focused to a large extent on content and content-specific pedagogy.

Results-driven. This type of staff development will measure its success in terms of changes in teacher knowledge and skills and improvements in student learning rather than through measurements such as continuing education units, staff development points earned for attendance at workshops, or other "seat-time" events. The National Board for Professional Teaching Standards (1997) provides one well documented means for assessing the knowledge and skills of accomplished teachers. Teacher portfolios, such as the ones used in Robbinsdale, Minnesota, provide another such process (Bradley, 1998).

Job-embedded and team based. "My analysis," Milbrey McLaughlin writes (1994), "is based on the view that teachers' professional development of the most meaningful sort takes place not in a workshop or in discrete, bundled convocations but in the context of professional communities-discourse communities, learning communities." (p. 31) While workshops and courses have their place in a comprehensive staff development effort, much of the important learning in a school needs to take place as teachers face the day-to-day challenges of their work (Darling Hammond, 1996).

Teacher and principal learning should occur through processes such as study groups (Mohr, 1998), coaching, action research (Calhoun, 1994), and the joint planning of lessons and critiquing of student work. "Teachers learn best by studying, doing, and reflecting; by collaborating with other

teachers; by looking closely at students and their work; and by sharing what they see," Linda Darling-Hammond writes (1998b) (p. 8). Consequently, the core staff development process occurs among a small group of teachers (eight to 12) who share a common responsibility within a school for educating all their students to high levels of learning and who meet several hours per week to refine their lessons, review student work, and discuss ways that instruction can be improved (Meier, 1998).

Time for such study may be found through changes in the school's schedule (Murphy, 1997) or through deeper changes in school organization (National Commission on Teaching and America's Future, 1996; National Education Commission on Time and Learning, 1994). Such changes will require new types of labor management contracts (Kerchner, Koppich, & Weeres, 1997).

Content-specific pedagogy. Recently-developed standards in the various academic disciplines require teachers to lead students to a depth of understanding that was often not present in their own college courses. Consequently, teachers themselves need opportunities to acquire deeper understanding of the content (Ball & Cohen, 1996; Darling-Hammond, 1998b; Lawton, 1998) and to be taught by teachers who model instructional practices appropriate to that content. This learning may occur through professional networks (Pennell & Firestone, 1998), professional assessment, teacher academies, and peer review (Darling-Hammond, 1996,1998a).

Concluding Remarks: The Teacher of Tomorrow

What roles, knowledge, competencies, skills and abilities does a professional educator need in the digital age? What steps should policy makers take to establish professional growth opportunities that will enable educators to reach this vision of teacher development? Following are some examples of actions that state policy makers can take.

Preservice Education

- Require teacher educators, through program approval, to demonstrate computer competency.
- Require teacher educators, through program approval, to actively use technology in their teaching as a way to provide role models to teacher candidates.
- Infuse technology throughout the program-approval standards and curriculum of teacher education.
- Ensure that preservice teachers receive instruction in using technology for student assessment.

Teacher Licensure

- Review teacher licensure requirements with respect to technology to ensure that they focus on how to use the computer for instruction as well as require that teachers demonstrate an ability to use high-end technologies such as multimedia and/or on-line activities.
- Explore the possibility of using electronically-based teacher assessments for part of the licensure requirement. Such assessments can provide results immediately and be cheaper to administer.
- States that require teachers to submit portfolios for licensure should explore the potential of portfolios submitted electronically.
- States that are using performance requirements for licensure should include a candidate's demonstrated use of technology in the teaching and learning process as one component of a successful performance examination.
- Require technology competency for licensure renewal.

Staff Development

- Require that state-supported staff development activities deepen teachers' understanding of the content that they are teaching and its application in real world settings, using technology.
- Develop statewide infrastructures that connect teachers to other professionals within the beyond their schools. Electronic teacher networks can serve as important sources of information, materials, and support. Networks external to the school can connect teachers to the latest

research and advances in their fields and to have interpersonal connections that enrich their work.

- Require that technology staff development plans focus on how to *integrate* the technology into instruction or on how to assess its benefits, not basic knowledge of how to operate computers and software.
- Support the development of on-line courses and CD- ROM packages.

Technology Infrastructure

- Require that district- and school-based technology plans include a strong evaluation component to determine if technology is being used in exemplary ways, i.e., employ cooperative learning, incorporate higher-level thinking skills, increase communication between students and teachers, relate the skills to "real life" situations, and be flexible enough to address different learning styles (Jordan and Follman, 1993).
- Update state technology plans to focus infrastructure work on equity with respect to access to hardware, software, and connectivity. *Technology Counts* reported that those schools with greater computer density, network access, and Internet access offer more professional development opportunities in instructional technology than schools in general (Milken, 1998b).
- School staffing assignments should consider clustering technology-using teachers in buildings. Studies show that schools with larger numbers of teachers using technology tend to have more exemplary technology users (Hadley and Sheingold, 1993).
- Funding for school-based technology coordinators should require that those coordinators provide support for teachers, not just students.

These recommendations are a few of the ways that technology can be used to support teacher development. As technologies improve and educators become more adept at their use, we will see greater numbers of teachers taking advantage of technologies that support their development. This, in turn, should enhance the quality of the teaching and learning process and, thus, student achievement.

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